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DEVELOPMENT OF AN ELECTROPHORETIC IMAGE DISPLAY

QUARTERLY TECHNICAL REPORT

November 1, 1981 to January 31, 1982

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display drive circuits

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this work is to develop an X-Y addressed electrophoretic image display. The problem of indium oxide redeposit onto the walls of the potential wells during ion-beam milling has been solved. A thin layer of SiO_x is evaporated over the row-patterned substrate prior to the application of the mylar dielectric. This layer shields the indium oxide during the ion-beam milling process and is subsequently removed by plasma etching. A sample cell for evaluation by ISI was delivered in January. It is anticipated over.

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20. ABSTRACT (Cont'd.)

that the yield of mylar EPID cells will be much higher than that in the past due to the SiO_x treatment. A number of cells were fabricated using the photopolymer technology; the cells performed satisfactorily. Bubbles in the suspension, however, have been a problem with these cells. Several causes are being investigated; the evolution of nitrogen gas and poor sealing may be the major contributing causes. Solutions to these problems are being investigated. Work on fixturing and testing procedures for the Phase II cells has begun.

PREFACE

This work is being performed by Philips Laboratories, a Division of North American Philips Corporation, Briarcliff Manor, New York under the overall supervision of Dr. Barry Singer, Director, Component and Device Research Group. Mr. Richard Stolzenberger, Physicist, is the Program Leader; Mr. Joseph Lalak, Electronic Engineer, is responsible for cell fabrication and technology. Mr. Karl Wittig, Electrical Engineer, is responsible for circuit design; Dr. Howard Sorkin, Organic Chemist, is responsible for electrophoretic suspensions.

This program is sponsored by the Defense Advanced Research Projects Agency (DARPA) and was initiated under Contract No. MDA903-79-C-0439. Dr. Robert E. Kahn is the Contracting Officer's Technical Representative for DARPA.

The work described in this tenth Quarterly Technical Report covers the period from 1 November 1981 to 31 January 1982.

SUMMARY

The purpose of this work is to develop an X-Y addressed electrophoretic image display. The problem of indium oxide redeposit onto the walls of the potential wells during ion-beam milling has been solved. A thin layer of SiO_x is evaporated over the row-patterned substrate prior to the application of the mylar dielectric. This layer shields the indium oxide during the ion-beam milling process and is subsequently removed by plasma etching. A sample cell for evaluation by ISI was delivered in January. It is anticipated that the yield of mylar EPID cells will be much higher than that in the past due to the SiO_x treatment. A number of cells were fabricated using the photopolymer technology; the cells performed satisfactorily. Bubbles in the suspension, however, have been a problem with these cells. Several causes are being investigated; the evolution of nitrogen gas and poor sealing may be the major contributing causes. Solutions to these problems are being investigated. Work on fixturing and testing procedures for the Phase II cells has begun.

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1. INTRODUCTION

A number of Phase I displays were fabricated and tested during this quarter. Cells were produced by ion-beam milling and by photopolymer technology. Both methods yielded satisfactory devices, but there were some technological problems associated with each.

The shorting due to indium oxide redeposit has been alleviated by evaporating a thin layer of SiO_x over the row-patterned substrate. Ion-beam-milled cells of good quality and high resistance can now be fabricated. Some pigment sticking remains as a problem in the ion-beam-milled cells. Pigment seems to accumulate in the wells with time.

The photopolymer technique has produced some fine displays with good contrast and virtually no pigment sticking. Bubbles in the photoresist and in the suspension fluid have been discovered, however, and steps are underway to resolve the problem. The repeatability of the photopolymer process for the 12 μm dielectric layer is less than desirable, and work is proceeding on controlling some process variables.

A driver was designed and built to take data from a Commodore "PET" computer and display it one line at a time on a Phase I display.

2. PHASE I

2.1 Fabrication Technology

During the previous quarter, the low resistances between rows and columns were found to be due to the redeposit of In_2O_3 onto the walls of the wells during ion-beam milling. High-angle milling, and etching in dilute aqua regia or dilute buffered hydrofluoric acid proved difficult to control and were only marginally successful. While improvements have been made in the uniformity of the ion beam by optimizing operating parameters,

the center of the substrate still receives more milling than the edges.

The most significant process change this quarter has been the introduction of a protective SiO_x layer which is deposited over the patterned row electrodes prior to bonding of the 12 μm Mylar dielectric. This layer shields the In_2O_3 from the ion beam, and thus essentially prevents central milling of the In_2O_3 and subsequent redeposit upon the walls of the wells while the periphery of the substrate reaches completion of milling. The SiO_x layer, however, is a dielectric and must be removed before assembly since it can hold an electrical charge which could interfere with proper device operation.

Linear plasma etching has been chosen over liquid etching for removing any residual SiO_x. From previous experience, we had found that the etchant, dilute buffered hydroflouric acid, attacks the bond between the Mylar and the evaporated column electrode.

A Technics Planar Etch II has been used to etch the SiO_x. Since the exact oxygen content is unknown, a gas mixture was chosen to match, approximately, the etch rates of silicon and SiO_2. This mixture consists of one part N_2, one part CF_4 and one part DE101*. The substrates are etched for 10 minutes at about 125 W of power using 30 cc total volume of gas per minute at a pressure of 200 mTorr.

With this etching process, we can now fabricate high resistance cells of good quality at a reasonable yield. About a half-dozen substrates were produced with this technique,and we expect to fullfill the Phase I requirements shortly with cells made from these substrates.

(*) DE101 is a mixture of 96.5% He, 3% CF_4 and 0.5% O_2.

2.2 Electronics

The drive electronics for the Phase I display was successfully completed and tested, and was used to generate text on a number of EPID devices. During this quarter, the hardware and software were debugged, system integration was completed, and the working driver was demonstrated.

Hardware. With the exception of correcting a few minor design errors, no design changes were made on the driver circuitry; it remains as originally described. Construction bugs were eliminated in the power supply and controller circuits, and the hardware is working properly.

Software. The software design also remained in its original form; there were only a few programming errors which needed to be corrected. The 8048 assembly language code was developed, debugged, and assembled on an Intel MDS development system using an ISIS-II operating system, a CREDIT text editor, and an ASM48 assembler. A program listing is shown in the Appendix.

System Integration. The assembled 8048 software was used with an ICE48 in-circuit-emulator to perform system integration. When the last remaining bugs were eliminated, a UPM PROM programmer was used to burn the debugged software into the resident program memory of the 8048 processor.

Operation. The completed driver was tested with various EPID devices, and performed all functions as expected. Individual lines of text, as well as full pages, were displayed under control of the host computer (a Commodore PET). Software routines were written for the PET to demonstrate the display. The driver responds to commands from the PET for writing a line of text, reversing the tone of an arbitrary sequence of characters and erasing/resetting the display. The ASCII codes for these three functions correspond to those which perform the analogous functions on the PET (LF, DC3 and DC1), respectively.

The IEEE-488 interface permits any computer to be used as a host provided the computer generates the same ASCII character sequences and is compatible with this interface. A photograph of a 64-character ASCII set displayed on an EPID device using this driver is shown in Figure 1.

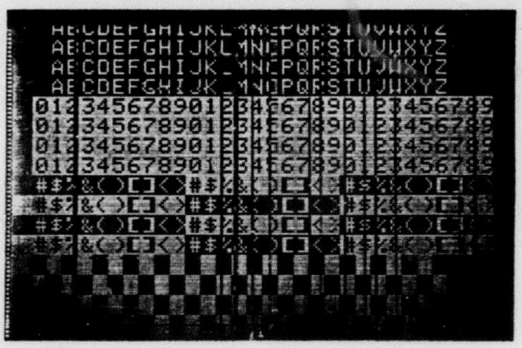

Figure 1

<u>Problems</u>. Although successfully demonstrated, the display system has two remaining problems. One is the need to adjust the electrode voltages for each individual device; this will eventually be remedied by higher tolerances on the device fabrication. The other is that, during the initial half-select condition, some of the pigment leaves the half-selected element, adversely affecting the brightness. The reasons for this are being investigated. A temporary solution is to half-select every row or column momentarily after resetting the display; this will eliminate the effect during writing.

3. PHASE II

3.1 Fabrication Technology

Work has continued on developing a photofabrication process for forming a thick photopolymer layer which will serve as the dielectric support for the control grid.

Sample photopolymer coatings supplied by Integrated Technologies, Inc. were evaluated and found to be 12 $\mu m \pm 1 \mu m$ thick and very uniform. In addition, the samples had very little edge rim. An order was placed for a "cavex" coater large enough to coat Phase II substrates. Delivery is scheduled for the end of March 1982.

Process development continued on the Shipley 1300 series photoresist. While some difficulty was experienced in controlling the process variables, many good substrates were produced. A serious photoresist bubbling problem, however, has continued to affect the 1300 series devices. The problem is believed to be caused by nitrogen which evolves during the photochemical reaction. If we define "venting factor" as the ratio of atmospherically exposed photoresist surface area to photoresist volume, then it seems that where the morphology of the structure presents a high venting factor, such as in the fine gridwork of the potential wells, no problem exists since the liberated nitrogen is free to emerge into the atmosphere. In the finger contact area, however, where the venting factor is low, the nitrogen collects under the In_2O_3 electrode and pushes it up to form a bubble which sometimes ruptures, forming a flap or loose piece of electrode. This, of course, is undesirable since flaps or loose pieces can cause shorts in the device.

Several approaches to this bubbling problem were investigated. Among them were: various prebake and postbake procedures, localized postbake of the finger area before photofabrication, and separate application and postbake treatment for the finger

and gridwork areas. None of these solutions were without problems such as thermal destruction of photosensitivity in adjacent areas and the creation of bumps and discontinuities in the coating. Finally, a new photoresist with less photoactive component was tried. Initial tests show an order of magnitude improvement in bubbling. The new resist is now being characterized to determine the correct processing parameters.

An active program has begun to either find or synthesize photopolymers which will improve device characteristics or facilitate fabrication. Materials such as photopatternable polyimides are being investigated.

Bubbles or voids in the suspension have been troublesome in the photofabricated cells, and while leaks and incompletely filled cells may be contributing factors, it is felt that nitrogen evolution may be at fault here also. Presumably, steps such as irradiating the cells with UV light before filling to evolve any residual nitrogen and changing to the new photoresist should alleviate this situation.

3.2 Results

Aside from the bubbling problem, the photoresist cells fabricated thus far have good contrast, relatively few defects, and virtually no sticking problems.

4. PLANS FOR NEXT QUARTER

a. Obtain masks and fixtures for Phase II devices.

b. Continue development of Phase II photofabrication techniques on Phase I size cells.

c. Complete Phase I.

d. Design driver for Phase II.

e. Improve suspension speed and contrast.

APPENDIX A

Assembly Language Code for EPID Controller

ASM48 :F1:DRIVER.ASM

ISIS-II MCS-48/UPI-41 MACRO ASSEMBLER, V4.0   PAGE   1

```
 LOC  OBJ          LINE        SOURCE STATEMENT

 0000 05              1 RESET:   EN I
 0001 0405            2          JMP INIT
 0003 24A8            3          JMP PWROFF
 0005 23E0            4 INIT:    MOV A,#11100000B     ;INITIALIZE INTEL 8291 IEEE-488 INTERFACE
 0007 39              5          OUTL P1,A
 0008 23C5            6          MOV A,#11000101B
 000A 3A              7          OUTL P2,A
 000B 2302            8          MOV A,#00000010B
 000D 02              9          OUTL BUS,A
 000E 2321           10          MOV A,#00100001B
 0010 02             11          OUTL BUS,A
 0011 23C1           12          MOV A,#11000001B
 0013 3A             13          OUTL P2,A
 0014 2301           14          MOV A,#00000001B
 0016 02             15          OUTL BUS,A
 0017 23C2           16          MOV A,#11000010B
 0019 3A             17          OUTL P2,A
 001A 2300           18          MOV A,#00000000B
 001C 02             19          OUTL BUS,A
 001D 23C4           20          MOV A,#11000100B
 001F 3A             21          OUTL P2,A
 0020 2301           22          MOV A,#00000001B
 0022 02             23          OUTL BUS,A
 0023 23C5           24          MOV A,#11000101B
 0025 3A             25          OUTL P2,A
 0026 2381           26          MOV A,#10000001B
 0028 02             27          OUTL BUS,A
 0029 23A8           28          MOV A,#10101000B
 002B 02             29          OUTL BUS,A
 002C 23C6           30          MOV A,#11000110B
 002E 3A             31          OUTL P2,A
 002F 2345           32          MOV A,#01000101B
 0031 02             33          OUTL BUS,A
 0032 23EF           34          MOV A,#11101111B
 0034 02             35          OUTL BUS,A
 0035 23C7           36          MOV A,#11000111B
 0037 3A             37          OUTL P2,A
 0038 230A           38          MOV A,#00001010B
 003A 02             39          OUTL BUS,A
 003B 23C5           40          MOV A,#11000101B
 003D 3A             41          OUTL P2,A
 003E 2300           42          MOV A,#00000000B
 0040 02             43          OUTL BUS,A
 0041 23C8           44          MOV A,#11001000B
 0043 3A             45          OUTL P2,A
 0044 2300           46          MOV A,#00000000B
 0046 A8             47          MOV R0,A
 0047 90             48          MOVX @R0,A
 0048 264E           49 NREV:    JNT0 TREV            ;CHECK TONE REVERSAL SWITCH
 004A BA00           50          MOV R2,#00000000B
 004C 0450           51          JMP SETROW
 004E BA80           52 TREV:    MOV R2,#10000000B
 0050 85             53 SETROW:  CLR F0               ;SET ALL ROW REGISTER BITS HIGH
 0051 B800           54          MOV R0,#00000000B
```

```
LOC   OBJ      SOURCE STATEMENT

0053 8910      RCLOCK:  ORL P1,#00010000B
0055 18                 INC R0
0056 F8                  MOV A,R0
0057 036C               ADD A,#01101100B
0059 99EF               ANL P1,#11101111B
005B 00                 NOP
005C 00                 NOP
005D 9653               JNZ RCLOCK
005F 997F               ANL P1,#01111111B
0061 8910               ORL P1,#00010000B
0063 00                 NOP
0064 00                 NOP
0065 99EF               ANL P1,#11101111B
0067 8980               ORL P1,#10000000B
0069 8910               ORL P1,#00010000B
006B 00                 NOP
006C 00                 NOP
006D 99EF               ANL P1,#11101111B
006F 00                 NOP
0070 00                 NOP
00071 8910               ORL P1,#00010000B
0073 00                 NOP
0074 00                 NOP
0075 99EF               ANL P1,#11101111B
0077 23C6               MOV A,#11000110B    ;ERASE DISPLAY
0079 39                 OUTL P1,A
007A B801               MOV R0,#00000001B
007C 2300      ERASE1:  MOV A,#00000000B
007E 62                 MOV T,A
007F 55                 STRT T
0080 1684      TIME1:   JTF COUNT1
0082 0480               JMP TIME1
0084 65        COUNT1:  STOP TCNT
0085 C8                 DEC R0
0086 F8                 MOV A,R0
0087 967C               JNZ ERASE1
0089 23E0               MOV A,#11100000B
008B 39                 OUTL P1,A
008C 8A10               ORL P2,#00010000B   ;SET DISPLAY
008E B802               MOV R0,#00000010B
0090 2300      ARRSET:  MOV A,#00000000B
0092 62                 MOV T,A
0093 55                 STRT T
0094 1698      TIME2:   JTF COUNT2
0096 0494               JMP TIME2
0098 65        COUNT2:  STOP TCNT
0099 C8                 DEC R0
009A F8                 MOV A,R0
009B 9690               JNZ ARRSET
009D 9AEF               ANL P2,#11101111B
009F BE00      SEQNCE:  MOV R6,#00000000B   ;BEGIN WRITE SEQUENCE
00A1 B920      CHLINE:  MOV R1,#00100000B
00A3 23E0               MOV A,#11100000B
00A5 39                 OUTL P1,A
00A6 23C8      TEST1:   MOV A,#11001000B    ;READY TO RECEIVE ASCII CHARACTER
```

```
LOC  OBJ         LINE        SOURCE STATEMENT

00A8 3A           110          OUTL P2,A
00A9 2300         111          MOV A,#00000000B
00AB A8           112          MOV R0,A
00AC 90           113          MOVX @R0,A
00AD 9AF7         114          ANL P2,#11110111B
00AF B6B5         115          JF0 READ1
00B1 46B5         116 TEST:    JNT1 READ1
00B3 04B1         117          JMP TEST
00B5 85           118 READ1:   CLR F0               ;RECEIVE ASCII CHARACTER
00B6 08           119          INS A,BUS
00B7 537F         120          ANL A,#01111111B
00B9 AB           121          MOV R3,A
00BA D2E2         122          JB6 ALPHA
00BC B2E2         123          JB5 ALPHA
00BE 03EE         124 KREV:    ADD A,#11101110B     ;TEST FOR TONE REVERSE CHARACTER
00C0 96CE         125          JNZ KERASE
00C2 FA           126          MOV A,R2
00C3 D380         127          XRL A,#10000000B
00C5 AA           128          MOV R2,A
00C6 23C5         129          MOV A,#11000101B
00C8 3A           130          OUTL P2,A
00C9 2303         131          MOV A,#00000011B
00CB 02           132          OUTL BUS,A
00CC 04A6         133          JMP TEST1
00CE FB           134 KERASE:  MOV A,R3             ;TEST FOR ERASE CHARACTER
00CF 03ED         135          ADD A,#11101101B
00D1 96D5         136          JNZ KNEWLN
00D3 2480         137          JMP END2
00D5 FB           138 KNEWLN:  MOV A,R3             ;TEST FOR ENDLINE CHARACTER
00D6 03F6         139          ADD A,#11110110B
00D8 C6F5         140          JZ FULL
00DA 23C5         141          MOV A,#11000101B
00DC 3A           142          OUTL P2,A
00DD 2303         143          MOV A,#00000011B
00DF 02           144          OUTL BUS,A
00E0 04A6         145          JMP TEST1
00E2 F9           146 ALPHA:   MOV AA,R1             ;TEST FOR ALPHANUMERIC CHARACTER
00E3 03C0         147          ADD A,#11000000B
00E5 96E9         148          JNZ STORE
00E7 240A         149          JMP DATSTP
00E9 FB           150 STORE:   MOV A,R3             ;STORE ALPHANUMERIC CHARACTER IN RAM
00EA 4A           151          ORL A,R2
00EB A1           152          MOV @R1,A
00EC 19           153          INC R1
00ED 23C5         154          MOV A,#11000101B
00EF 3A           155          OUTL P2,A
00F0 2303         156          MOV A,#00000011B
00F2 02           157          OUTL BUS,A
00F3 04A6         158          JMP TEST1
00F5 23C5         159 FULL:    MOV A,#11000101B     ;FILL REMAINDER OF LINE WITH BLANKS
00F7 3A           160          OUTL P2,A
00F8 2303         161          MOV A,#00000011B
00FA 02           162          OUTL BUS,A
00FB 23C8         163          MOV A,#11001000B
00FD 3A           164          OUTL P2,A
```

```
LOC  OBJ         LINE         SOURCE STATEMENT

00FE F9           165 WRITE1:  MOV A,R1
00FF 03C0         166          ADD A,#11000000B
0101 C60B         167          JZ WRITE2
0103 2320         168          MOV A,#00100000B
0105 4A           169          ORL A,R2
0106 A1           170          MOV @R1,A
0107 19           171          INC R1
0108 04FE         172          JMP WRITE1
010A 95           173 DATSTP:  CPL F0
010B BD00         174 WRITE2:  MOV R5,#00000000B    ;LINE DISPLAY SEQUENCE
010D B920         175 WRITE3:  MOV R1,#00100000B
010F F1           176 WRITE4:  MOV A,@R1
0110 F216         177          JB7 REV
0112 99F7         178          ANL P1,#11110111B
0114 2418         179          JMP LOAD
0116 8908         180 REV:     ORL P1,#00001000B
0118 FD           181 LOAD:    MOV A,R5             ;LOAD CHARACTER IN COLUMN DRIVER
0119 43C8         182          ORL A,#11001000B
011B 3A           183          OUTL P2,A
011C F1           184          MOV A,@R11
011D 02           185          OUTL BUS,A
011E 00           186          NOP
011F 00           187          NOP
0120 00           188          NOP
0121 00           189          NOP
0122 BC07         190          MOV R4,#00000111B
0124 8901         191 CCLK:    ORL P1,#00000001B    ;SHIFT COLUMN DRIVER
0126 CC           192          DEC R4
0127 FC           193          MOV A,R4
0128 00           194          NOP
0129 00           195          NOP
012A 99FE         196          ANL P1,#11111110B
012C 00           197          NOP
012D 00           198          NOP
012E 9624         199          JNZ CCLK
0130 19           200          INC R1               ;INCREMENT CHARACTER
0131 F9           201          MOV A,R1
0132 03C0         202          ADD A,#11000000B
0134 C638         203          JZ WRITE
0136 240F         204          JMP WRITE4
0138 2300         205 WRITE:   MOV A,#00000000B     ;WRITE ROW
013A 62           206          MMOV T,A
013B 99BF         207          ANL P1,#10111111B
013D 8902         208          ORL P1,#00000010B
013F 55           209          STRT T
0140 1644         210 TIME3:   JTF COUNT3
0142 2440         211          JMP TIME3
0144 65           212 COUNT3:  STOP TCNT
0145 99FD         213          ANL P1,#11111101B
0147 8940         214          ORL P1,#01000000B
0149 8910         215          ORL P1,#00010000B
014B 00           216          NOP
014C 00           217          NOP
014D 00           218          NOP
014E 00           219          NOP
```

```
LOC  OBJ          SOURCE STATEMENT

014F 99EF                 ANL P1,#11101111B
0151 1D                   INC R5                 ;INCREMENT ROW COUNTER
0152 FDD                  MOV A,R5
0153 03F7                 ADD A,#11110111B
0155 C659                 JZ  NXTLN
0157 240D                 JMP WRITE3
0159 1E          NXTLN:   INC R6                 ;INCREMENT LINE COUNTER
015A FE                   MOV A,R6
015B 03F0                 ADD A,#11110000B
015D C661                 JZZ ENDO
015F 04A1                 JMP CHLINE             ;RETURN TO WRITE SEQUENCE
0161 B665        ENDO:    JFO END1               ;END SEQUENCE
0163 246C                 JMP ENDF
0165 85          END1:    CLR F0
0166 2385                 MOV A,#10000101B
0168 3A                   OUTL P2,A
0169 2303                 MOV A,#00000011B
016B 02                   OUTL BUS,A
016C 2388        ENDF:    MOV A,#10001000B
016E 3A                   OUTL P2,A
016F 2300                 MOV A,#00000000B
0171 A8                   MOV R0,A
0172 90                   MOVX @R0,A
0173 9AF7                 ANL P2,#11110111B
0175 4679        TEST2:   JNT1 READ2             ;TEST FOR ERASE CHARACTER
0177 2475                 JMP TEST2
0179 08          READ2:   INS A,BUS
017A 537F                 ANL A,#01111111B
017C 03ED                 ADD A,#11101101B
017E 9665                 JNZ END1
0180 23C5        END2:    MOV A,#11000101B
0182 3A                   OUTL P2,A
0183 2303                 MOV A,#00000011B
0185 02                   OUTL BUS,A
0186 23C8                 MOV A,#11001000B
0188 3A                   OUTL P2,A
0189 2300                 MOV A,#00000000B
018B A8                   MOV R0,A
018C 90                   MOVX @R0,A
018D 9AF7                 ANL P2,#11110111B
018F 4693        TEST3:   JNT1 READ3             ;TEST FOR ENDLINE CHARACTER
0191 248F                 JMP TEST3
0193 08          READ3:   INS A,BUS
0194 537F                 ANL A,#01111111B
0196 03F6                 ADD A,#11110110B
0198 9680                 JNZ END2
019A 23C5                 MOV A,#11000101B
019C 3A                   OUTL P2,A
019D 2303                 MOV A,#00000011B
019F 02                   OUTL BUS,A
01A0 23C8                 MOV A,#11001000B
01A2 3A                   OUTL P2,A
01A3 23E0                 MOV A,#11100000B
01A5 39                   OUTL P1,A
01A6 0448                 JMP NREV               ;RETURN
```

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 LOC  OBJ          LINE        SOURCE STATEMENT

 01A8 23C8          275 PWROFF: MOV A,#11001000B    ;POWER-DOWN SEQUENCE (INTERRUPT-INITIATED)
 01AA 3A            276         OUTL P2,A
 01AB 23C6          277         MOV A,#11000110B    ;ERASE DISPLAY
 01AD 39            278         OUTL P1,A
 01AE B801          279         MOV R0,#00000001B
 01B0 2300          280 ERASE2: MOV A,#00000000B
 01B2 62            281         MOV T,A
 01B3 55            282         STRT T
 01B4 16B8          283 TIME4:  JTF COUNT4
 01B6 24B4          284         JMP TIME4
 01B8 65            285 COUNT4: STOP TCNT
 01B9 C8            286         DEC R0
 01BA F8            287         MOV A,R0
 01BB 96B0          288         JNZ ERASE2
 01BD 9A7F          289         ANL P2,#01111111B   ;REMOVE POWER
 01BF 24BF          290 GSTOP:  JMP GSTOP
                    291         END

USER SYMBOLS
ALPHA  00E2   ARRSET 0090   CCLK   0124   CHLINE 00A1   COUNT1 0084   COUNT2 0098   COUNT3 0144   COUNT4 01B8

DATSTP 010A   END0   0161   END1   0165   END2   0180   ENDF   016C   ERASE1 007C   ERASE2 01B0   FULL   00F5
INIT   0005   KERASE 00CE   KNEWLN 00D5   KREV   00BE   LOAD   0118   NREV   004B   NXTLN  0159   PWROFF 01A8
GSTOP  01BF   RCLOCK 0053   READ1  00B5   READ2  0179   READ3  0193   RESET  0000   REV    0116   SEGNCE 009F
SETROW 0050   STORE  00E9   TEST   00B1   TEST1  00A6   TEST2  0175   TEST3  01BF   TIME1  0080   TIME2  0094
TIME3  0140   TIME4  01B4   TREV   004E   WRITE  0138   WRITE1 00FE   WRITE2 010B   WRITE3 010D   WRITE4 010F

ASSEMBLY COMPLETE,    NO ERRORS
```

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